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ABSTRACT

Early involvement in research with actively participating faculty should not only speed and enhance the learning process, but also motivate students toward science. To gain firsthand information on how this concept works in actual practice, a conference on Research at the Undergraduate Level was held. All 16 participants were from universities with active undergraduate research programs. Among the themes developed for the report were the following: (1) Research as a Teaching Technique; (2) What is a Good Undergraduate Research Problem; (3) What Assistance is Needed for the Faculty Member; (4) The Best Time for Undergraduate Research; (5) Managing a Research Program; (6) Getting Students Involved in Research; (7) A Productive Research Environment; (8) Getting Inactive Faculty Back Into Research; (9) What Results Can be Expected from Undergraduate Research; (10) The Cost of Research; and (11) What Does the Future Hold? (RH)

REPORT OF A CONFERENCE ON

RESEARCH AT THE UNDERGRADUATE LEVEL

Sponsored by Research Corporation

Callaway Gardens

Pine Mountain, Georgia

April 13-16, 1975

RESEARCH CORPORATION
A Foundation for the Advancement of Science
405 LEXINGTON AVENUE, NEW YORK, NEW YORK 10017

Conference on

Research at the Undergraduate Level

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REPORT OF A CONFERENCE ON

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INTRODUCTION

Research is described by Webster as "studious inquiry or examination; esp: critical and exhaustive investigation or experimentation having as its aim the discovery of new facts and their correct interpretation, the revision of accepted conclusions, theories, or laws in the light of newly discovered facts, or the practical application of such new and revised conclusions, theories, or laws."

This definition is consistent with the goals of science training at the various levels of higher education, and can be interpreted to involve all in that community -- students and their instructors.

Research, then, is a part of the learning process by which a student becomes a scientist, and it is an avenue of continuing intellectual attainment and challenge for the faculty. It follows that early involvement in research with actively participating faculty should not only speed and enhance the learning process, but perhaps "capture" for science some who might not otherwise be so motivated.

To gain firsthand information on how this concept works in actual practice, Research Corporation sponsored in May 1975 a conference on Research at the Undergraduate Level. The 16 participants, chosen on the basis of their interest and proficiency with such programs in the natural sciences, represented a wide range of institutions from small privately-supported liberal arts colleges to publicly-supported universities with extensive graduate programs. All were running active undergraduate research programs. Table I summarizes their activities.

Table I

PROFILE OF CONFERENCE PARTICIPANTS*

	Representatives of Nine Undergraduate Colleges	Representatives of Four Universities with Small M.S. Programs
Average research support requested over three years	$34,000	$41,000
Average support received	$25,000	$15,000
Undergraduates/M.S. candidates supported per year	4	1.2/1.2
Number publications over three years	3+	2-
Hours per week research during academic year	10	13
Contact hours teaching load	11	7

*Representatives of the three large universities are not included since their undergraduate and graduate student costs and accomplishments could not be segregated.

Major emphasis was placed by the participants on research as teaching, as well as a professional activity. The skillful blending of classroom instruction with research experience -- of reading and hearing about science, then going into the research environment and actually doing it -- was agreed upon as a concept of positive value to the training of students, to the continuous stimulation of faculty members, and to the establishment of a professional atmosphere in the institution.

Following are some of the themes developed at the conference, along with additional material furnished by the participants following the meetings.

RESEARCH AS A TEACHING TECHNIQUE

Science as a discipline is developing continuously; change is the norm. As a result a science teacher must constantly master new knowledge and new techniques and then incorporate both into the educational system. Without a mechanism to facilitate this continuing education the teacher will be unable to function effectively.

The undergraduate science student is in an analogous position. He must learn an ever-expanding number of techniques, keep abreast of new developments and, at the same time, acquire the background necessary for understanding.

One option for assisting both the faculty and students in this enterprise in continuing education is to involve them in joint research.

A recent study[1] at Kansas State University involving analysis of student evaluation of instructors indicated an

(1)"Faculty Research Involvement and Instructional Outcomes." Donald B. Hoyt and Ronald K. Spangler. Office of Educational Research. Kansas State University Research Report No. 30.

apparent linear trend between the degree of research involvement of the faculty, on the one hand, and the amount of reading and perceived difficulty of the course on the other. In the natural sciences, adjusted student progress ratings steadily increased as the instructor's level of research involvement increased. It was determined that faculty with heavy research responsibilities appeared to set higher academic standards than those less involved. Students of faculty members most involved in research scored significantly higher than did those whose teachers had moderate or little research involvement. The authors concluded, "This finding offers some support to those who contend that research involvement helps broaden the teacher and thus improves his ability to foster broad understanding and appreciation of intellectual matters among students."

Faculty members and students can sustain their interest in research best when they are involved in real problems -- problems having the potential for advancing science. Therefore, a good research problem is typically one which is able to withstand the scrutiny of the investigator's peers. Just as many musicians find it vital to perform publicly, active scientists find it desirable to publish and present talks or seminars on their research in order to gain the full appreciation for their efforts.

It is difficult for a scientist to sustain this research activity in the absence of co-workers, or at least colleagues

interested in the work. In the graduate institution, where the atmosphere is generally conducive to research, this assistance may be obtained from graduate students or from postdoctoral fellows. In the undergraduate institution the faculty member must to a very great extent rely on undergraduates to assist in the research activities and to sustain this enthusiasm. Often a more experienced colleague is desirable; at some institutions postdoctoral students or teaching interns have fulfilled this role. Other institutions have used retired industrial or academic scientists in a similar manner. One such example is found in the biology department of Hiram College where Dr. Grace Pickford has for five years since her retirement from Yale University carried on an active research program with undergraduate student colleagues. Recently it was announced[2] that Drew University will use the services of a retired industrial chemist in a similar fashion.

Whatever the mechanism, undergraduates who are given an opportunity to broaden their education by becoming colleagues with faculty in research will gain from the experience in many ways. From the early elementary grades, the student's educational experience consists almost exclusively of taking courses and passing examinations. As an undergraduate, he needs the

(2) Chemical & Engineering News, March 8, 1976. p.16.

opportunity to practice what is being learned in the classroom, and this can very well take the form of active research participation. If this is to be a meaningful experience, however, the undergraduate researcher must take on the same goals as those of the faculty. This means maintaining high standards in the research which is undertaken and striving to bring the work to a publishable form. Such research is not a game and does not involve reinvestigation of known systems. The object of the research should be success! With the pursuit of such goals the student will learn what science really is, and what the practicing scientist really does.

As a participant in this activity the student has an unusual opportunity to mature as a scientist. Such work is excellent preparation for either graduate school or industrial employment. In the process the student may develop independence and provide stimulus and enthusiasm for the faculty member, while providing the assistance needed to keep the research program active. If the research undertaken is really designed as "studious inquiry or examination," the undergraduate will mature in a way which does not readily result from more formal classroom offerings. The research gives the student the opportunity to see his or her own creativity in action.

Educational advantages of undergraduate research participation suggested by the conference participants included:

- Research is creative, whereas classroom work may have a greater tendency to be a memorization process.
- Research helps the student learn about himself or herself.
- Science is, after all, an art. It is hard to teach this in a course since the procedure is so programmed. But in the research laboratory, the student learns appreciation of the subject which carries over to appreciation of what is being learned in the classroom. This leads to appreciation of the work of others.
- Research teaches the techniques of record keeping and literature searching.
- Research teaches the student that science is personal -- that people do these things.
- The undergraduate student may learn at an earlier stage that science is not his or her forte due to the many frustrations involved.

Research, therefore, takes science education out of the realm of theory, giving the student a chance to apply the abstract to the actual. Even the brightest of students often has trouble in the research laboratory, for the answers to questions to be resolved require creative effort.

The choice of a research problem which will involve undergraduate students is of utmost importance. It should be challenging, and have the potential to lead to new information. At the same time, it should parallel to some extent the student's abilities, and be consistent with the student's own personal interests.

Research activity by faculty members and support for such activity will result in greater faculty confidence, in familiarity with the discipline, and in a faculty which remains

alive and enthusiastic. It will enhance the recruitment and retention of well-qualified teachers. For the undergraduate college, no other single factor is so important as the quality of its faculty. Research by faculty enriches the undergraduate course offerings both in depth and in breadth. Innovative courses in new areas will be introduced and more detailed and precise study within present subject matter will be undertaken.

The value of faculty research extends to undergraduates who are not directly involved. These students will have an opportunity to see research going on around them and will begin to realize its importance. The professor doing the research will often be held in greater esteem by the students.

In order for a research problem to sustain itself over a long period of time, a certain number of investigators -- a "critical mass"-- seems to be required. The size of the group needed depends, to a very great extent, on the nature of the problem, but it is seldom that a one-person research operation is successful. This is certainly true if the single researcher is an undergraduate student. A person working alone will have difficulty evaluating progress which is being made. A group of investigators generally guarantees that a project will sustain itself to the point of completion.

An excellent esprit de corps is often observed among undergraduates involved in summer research with faculty

colleagues. However, an atmosphere of isolation may result if only one or two students are doing research. A spectrum of students at different levels of proficiency gives a program a continuity that may be helpful.

The number of students required to make up a "critical mass" depends upon the nature of the problem undertaken, as well as the ability of the faculty member to coordinate a group. Regardless of the size of individual groups, however, it seems desirable to have a number of groups operating. At institutions which have had considerable success in research at the undergraduate level, it is common for several such research groups to be active at any given time. Although these may be involved in unrelated activities, they tend to gain impetus from the knowledge that others are also active in research.

Alternatively, groups may be involved in team activities undertaking cooperatively the study of a particular topic. In this case several different "thrust groups" may be organized, with each responsible for pursuing one particular area of an overall problem. As part of such a scheme, it is very desirable to have the individual groups meet on a regular basis to discuss their respective activities. This approach may be coordinated with the activities of graduate students, but some attempt must be made to see that the undergraduates have a personal sense of responsibility and accomplishment in the work undertaken.

The "thrust group" idea may be better suited to the large department or institution. In smaller departments and institutions it may be impossible to put together adequately trained "thrust groups."

It may also be difficult to get faculty members to steer their research activity in directions not of personal interest to them, or not consistent with their previous training. In such cases it may be advisable for the participants to work on their invidivual projects, but to try to build some cooperation when this seems feasible.

WHAT IS A GOOD UNDERGRADUATE RESEARCH PROBLEM?

A good research problem is one which has as its overall goal a publication which will be of interest to the scientific community.

For the individual student, termination of the project may come earlier, but there should, nevertheless, be a final goal limited enough to allow the student a reasonable chance to reach it. The individual's activities then may be a part of a larger and more comprehensive problem, but in each case the student will be made to feel that he or she has contributed to the final publication.

A good research problem is usually one that the faculty member is personally interested in, one that the individual is willing to call "my life's work." Too often research is represented by what might better be called the "little project." Such "little projects" often prove to be too expensive and too inefficient to be considered viable, and some of them might better be done as special projects in conjunction with a course laboratory.

The most important requirement for good research is having a competent faculty. At the time of hiring, a department head must consider whether the research interest of the candidate fits into the activities of the department, and should describe fully what, if anything, will be expected with regard to research. By considering this at the time of employment, departments can select faculty members who will stimulate research.

Some may question whether a small science department can profit from selecting all of its faculty members with common research interests. Such an approach has worked well in some institutions and in some disciplines, but has been found to be less satisfactory in others. Certainly, diversity of interests is desirable as a means of creating a representative atmosphere within the science department. Interdepartmental research activity is another means of providing an element of diversity. Many environmental and ecological problems which are of interest to students are best tackled with an interdisciplinary approach.

The research interests of a professor in a small liberal arts college may be quite different from those of faculty members in graduate institutions. In either case, the faculty member should undertake for lifetime work that which appears to be interesting and important, and must be willing to publish the results of such investigation in order to be exposed for peer examination. The undergraduate student then becomes

a part of the team with the faculty member and must operate under the same standards. The goal of publication determines to a great extent, the nature of the problem which is to be attacked. To reach this goal the investigator tends to focus the research in an effective manner. Publications add great value to student morale, especially where cooperation with faculty is involved.

Competitiveness, or competition, may be a complicating factor in research when publication is to be the end result. This must be taken into consideration in the design of a problem, and is of special importance to the investigator in the small, undergraduate college. If a faculty member in such an institution plans to get involved in a very competitive field, it is often desirable to work in conjunction with colleagues in a graduate institution.

One of the most convenient ways for getting the undergraduate student started in an active research problem is through association with an ongoing project. It is to the student's advantage to start the research while working with a more experienced student. This can be done most conveniently during the summers when the students can devote full time to the project. It is advantageous to have overlap between senior students terminating their research activities and lower level students just beginning their own. It is to the student's

advantage to start research as early in the academic career as possible, and there are examples of successful students who have actually begun during their freshman and sophomore year. Often they began as assistants to upper level students, gaining increasing independence over years of participation in the project.

A good research problem for teaching purposes is not only one that involves several different laboratory techniques, but one which offers experience in both theoretical and applied aspects of the problem. The undergraduate student should have the opportunity to become involved in as many parts of the problem as possible. Since it is important for the student to be successful in some aspect of the project early in the investigation, the faculty member should take this into consideration in the design. The student should have the experience of helping to define the problem, doing the literature search, carrying out a portion of the project, and finally writing up some of the results.

In all cases it should be foremost in the mind of the faculty member that the undergraduate student is, in fact, a student. Thus one of the most important aspects in the design of a problem is that it teaches something not learned by the normal classroom or text book experience.

In order to sustain the interest of the student, the project

must contain considerable variety so that the individual does not become bored with repeating the same techniques continuously or with acquiring routine data with little variation.

Whenever possible, it is desirable to give the student the opportunity to help choose the project to be undertaken, and to have some input in its design. The extent to which this can be done depends on the time available and the sophistication of the student. If a project is to be successful, the student should be committed to it, rather than being required to be a participant.

The faculty member who is able to envision a comprehensive research program can offer the individual undergraduate student the opportunity to undertake a unique portion of the overall project. With this approach the work of several students will then form the eventual publication. Thus, the research interests of the faculty member can remain fairly broad in scope, whereas those of individual students can be much more limited. Too much diversity in the individual research group may be unworkable since it may make advising impossible. This is particularly important in predominantly undergraduate institutions where faculty members have many other commitments. Too broad a diversity of interests may also hinder the progress of research. A more concentrated problem allows the faculty member to have a group of colleagues -- the undergraduate students --

who may become excited about the same thing.

There are circumstances in which it is desirable for the faculty member in a small institution with limited facilities to engage in productive research by collaborating with a university faculty member in a neighboring institution. In such instances, the undergraduate faculty member and the students may be able to spend time during the summer on the university campus and, in so doing, gain many of the advantages of research participation. Obviously the instrumental resources, professional interactions, and services available at the university offer real advantages.

Whenever possible, however, it is advantageous for the research to be carried out on the home campus. The existence of a continuing research program on the campus provides an atmosphere and a research model that is infectious. It offers the maximum of exposure-contact between the instructor and the students. It establishes a professional atmosphere in the department.

It does seem necessary to distinguish between a "laboratory project" and "research." The laboratory project may involve independent work on the part of the student, and the answer to the project may not be known, but such a project is quite often of a routine nature and more pedagogical in its impact. The good research problem is one in which the faculty member

makes a personal commitment, has a degree of expertise, and is willing to pursue with dedication to its future success.

WHAT ASSISTANCE IS NEEDED FOR THE FACULTY MEMBER?

The academic level at which the student can participate profitably in research depends on many factors, including his or her background and preparation, the nature of the project, and the support help which will be available. If the project is broad in scope, the faculty member may work out a flexible arrangement involving students at various stages of academic training.

Graduate students, when available, can be of considerable assistance in keeping an active undergraduate research program going, particularly during the academic year. The faculty member must guard against giving them attention to the exclusion of the undergraduates, however, for the result may be loss of stimulation and motivation on the part of the younger students. The faculty member also suffers from loss of contact with the undergraduate mind.

One often hears the statement made that terminal master's degree students are generally not as good as the institution's undergraduates. Usually, such students are not as weak as is

assumed. What is it about undergraduates that they are judged to be better workers than the graduate students in this situation? Perhaps the undergraduate student is special to the faculty member because the development has been watched from the time of entry into the institution through graduation; the teacher gains satisfaction from the progress of the student. The terminal graduate student, on the other hand, enters the institution at an advanced level and as a new and unfamiliar figure. This individual is entitled to compete with the faculty member in ways which are beyond the undergraduate; after all, there are very few years separating the graduate student from faculty status. Finally, faculty members generally expect less of undergraduates and see more of them.

Graduate students are often excellent in training undergraduate research workers, in teaching techniques and familiarizing them with equipment. The graduate student can increase the participation of the undergraduate in the overall research activity. Graduate students are generally professionally oriented and create a contagious atmosphere of professionalism.

In the strictly undergraduate institution, the faculty member must have time available to compensate for lack of the professionally oriented help. Continuity of the research under these circumstances can be built into a project by encouraging undergraduates to participate in research early in their academic

training and allowing them to proceed throughout their entire program. The student who has participated in research in this fashion for several years will be deeply engrossed in the work and will be in a position not dissimilar to that of the master's student when it comes to training other students in techniques.

The presence of a postdoctoral fellow can be of great value to the professor participating in research with undergraduate students. Such fellows will bring into a research group new ideas and techniques, and will infuse a high level of professionalism into the laboratory. Such individuals also make it possible to maintain continuity in the research problem difficult to obtain by any other means. Postdoctoral fellows and postdoctoral teaching interns are not uncommon in undergraduate colleges which have demonstrated a high level of research proficiency. Thus, four of the nine participants from strictly undergraduate colleges at the conference came from departments with some postdoctoral students.

In the absence of postdoctoral assistance, research technicians may be used to accomplish similar goals, although at a lower level of efficiency.

The difficulty in any of these approaches is finding the money to support such programs. It should be pointed out that there are funding agencies which will support either postdoctoral students, or, in some cases, technicians, in strictly undergraduate

institutions when a sufficiently strong case can be presented. The presence of postdoctoral associates is fairly common in graduate institutions, though they are too seldom utilized in training undergraduate students or in assisting a faculty member who is interested in training undergraduates.

Some institutions have compensated for the lack of funds for professional help by furnishing retired scientists, either from industry or from academic institutions, with space for research and a small amount of money for supplies. Such a retired individual, involved full time in research activities, can act as a visual model to the undergraduate student and can, in addition, give good training to the student fortunate enough to have this experience.

The existence of some form of postgraduate assistance -- whether this be a graduate student, postdoctoral researcher, or retired person -- is of value to the research activities of the institution since it makes possible discussion of scientific topics at a level above that of the students. Such discussion may otherwise be lacking, especially when the faculty member is considered by the undergraduates to be an expert. The presence of postgraduates also facilitates the undergraduate student's quest for new knowledge since it is easier to ask them questions than it is a faculty member. Nevertheless, many productive research groups operate in the absence of this kind of assistance.

THE MOST PROFITABLE TIME FOR UNDERGRADUATE RESEARCH

Traditionally undergraduates who have been interested in participating in independent study or research have registered for a special course during the academic year and participated in this activity along with regular classroom work. In recent years opportunities have been available for students to spend full time on research during the summer and, depending upon the academic calendar used, during various interim terms. In considering research during the academic year, it must be remembered that the present level of classroom work is higher than in the past, and it is difficult to find students with free time. The student who attempts to do research solely during the academic year must be a well-organized individual, able to overcome various distractions. Also, the problem undertaken must be one that can be worked on in small bits and pieces, consistent with the time which will be available. Such an arrangement is not always satisfactory for the sort of faculty-student research activity previously described.

Research participation on a full-time basis during the summer months seems to overcome many of these complications. The summer offers large blocks of uninterrupted time. It is possible for the undergraduate student and the faculty to devote in excess of 400 hours to research during the summer. These are often more effective hours than a comparable amount of time in smaller segments during the academic year.

It is also possible for an individual undergraduate student to be involved in a project for more than one summer, thus expanding considerably the research involvement. Full-time summer research activity also seems to be more in keeping with the practice of research in the real world where one finds laboratory workers devoting their full working day, each day of the week, to an assigned problem. There is a more reasonable prospect of major accomplishment stemming from summer research than from a project conducted during the academic year. If publication is to be a goal of the research, summer participation is nearly mandatory.

The academic year can be used by the research group to organize experiments, interpret data, assemble equipment, and for similar activities. But even this use of time may be inefficient, and sometimes undesirable. General academic service required of all faculty members undermines faculty-student research during the academic year. At many institutions committee

assignments become nearly overwhelming and with preparation for classes all of the time of the faculty member outside the classroom may be consumed. When the faculty is not available in the research laboratory, the undergraduate student is generally handicapped. This problem can be overcome to a degree by the use of group dynamics, the use of upperclassmen in helping beginning research students, and the assistance of graduate students when available. In the case of group projects, bi-weekly seminars of the entire group may help keep the project under control and moving, and may serve to establish goals during this period. But none of these is a true substitute for summer research involvement.

There are many instances in which academic year work has been productive. The conference participants were generally agreed that undergraduates, particularly if registered for research as a course, may be expected to work from 10 to 15 hours per week on a project, but any more than this may not be realistic.

The amount of time which the faculty member will be able to devote to research and to working with students during the academic year is based to a significant extent on the attitude of the particular faculty member toward the importance of research as opposed to course offerings. Many young faculty members are sensitive to the college's internal and external pressures. All

of these conditions make research during the academic year difficult. It should be remembered that if a research project is not kept active during the academic year, even if at a reduced level, a serious lack of continuity in the learning process of the student may result, and certainly the progress made in the research will be slowed.

The academic year may sometimes be used to advantage in starting students on their research programs if this period is devoted to the training, learning techniques, and becoming familiar with instrumentation. Such an approach can significantly accelerate the student's progress during a summer research project.

A further complication of research during the academic year is the tendency for the student to put course work over research commitments, or sometimes vice versa. This can be overcome if prior to initiation of the research, the supervisor bargains or contracts with the student to assure a commitment to be in the lab at certain times. It is very important to see that the student is conscious of this commitment, since such responsibility is a part of the educational training derived from research. Academic credit may lead to another way to control this problem, but even this requires careful surveillance.

The academic year can also be used effectively in writing papers based on the summer's activities as well as in preparing proposals for research support.

The so-called interim term, or January semester, is often a difficult time to accomplish anything in the way of research in the natural sciences, although it may be very profitable in some other disciplines. For the student not already involved in a project, the startup time generally will consume the entire available period and little in the way of positive results will be realized. On the other hand, for the student already involved in a research problem, the interim term may be a pleasant interlude, allowing time for a few intensive experiments or for calculations and interpretation of data.

Thus it appears that the summer is the most productive time for research involving undergraduates, but the supervisor of such work must be aware of some complications. For example, the undergraduate student may become bored with this one activity, particularly if early successes are not achieved. Some special diversions may be needed to sustain the interest of the young researcher, such as topic seminars or field trips. The presence of summer school students at the institution may also complicate life for the student researcher since summer programs are generally populated by weaker students and their presence may lead to various distractions.

MANAGING A RESEARCH PROGRAM

The actual procedure for managing a research program depends, to a very large extent, on the nature of the project, the discipline involved, and the personnel. It is not unusual for up to three years to be required to get to the publication stage in a project involving faculty and undergraduate students. Initially, the undergraduate student may not be able to work independently and may, in fact, serve as an assistant. It is not unusual for the first year of such a project to be spent in the assembly of the equipment and the second year in getting equipment on line and in completing trial runs. In this case it may not be until the third year that hard data begins to emerge. Participation in a project of this sort may be a rich experience for the student and will offer the opportunities of associating with a practicing scientist and working with sophisticated equipment. This is a valid learning experience, not unlike what a graduate student may do in a similar academic program.

In other types of projects, and in some disciplines, it may be possible for the student to get started on a project immediately, and one summer, or one year, may prove a satisfactory period for accumulating enough data for a respectable publication.

In any case, there are some generalizations which can be made relative to the management of the research project. One of these is that a successful program depends upon establishing an attitude toward undergraduate research which renders it a prestige activity and a valuable part of the training of students. For this reason it is preferable to call and to conduct the activity as "research-teaching." If some of the faculty display this very positive attitude, more reluctant faculty members within the department and in other departments may slowly come around to their way of thinking -- especially when they observe the enthusiasm of both participating faculty and students.

In order to establish this attitude in a department, it is necessary to see that the faculty members participating in research with undergraduates are given recognition for their efforts by those in authority and by those possessing special prestige in the community.

It will be necessary for faculty members to continually encourage the undergraduate researcher, and to assure that hurdles are not put in the way. A project will only be successful if all

those participating are really committed, interested and enthusiastic. It will also be necessary for the research supervisor to establish procedure for measuring progress. This may entail setting goals for the various aspects of the problem, and designing a method for periodic evaluation -- perhaps through personal discussion, seminars, examination of notebook records, and so forth. It will certainly involve preparation by the student of periodic, concise, and clear reports on the progress made.

There would appear to be a limit as to how many students one faculty member can accommodate in a research project. It is difficult to establish any particular figure since it depends so much on the individual faculty member, the pressures of time, the style of the research, the nature of the project and its demands, and the availability of necessary equipment and space. It was generally agreed by conference participants that four undergraduates would present a full supervisory load for research which involves full-time activities during the summer and a reduced level of participation during the academic year. The most workable arrangement seems to be to have two students who are involved in research for the second summer, together with two students just beginning their research experience. By using the former two to train the new investigators, the faculty member can be relieved of some of the responsibility and is able to

concentrate more effort on the aspects of the problem which require the best efforts of the senior investigator. The number of student researchers working with conference participants from the strictly undergraduate colleges ranged from one to seven. In the case of the university participants the range was from zero to four.

If research is to be considered a valid part of the training of students, faculty members should certainly receive credit towards their participation in the calculation of credit-hour loads. To do this, an institution must establish the priority it plans to give to research and must adjust its commitments accordingly. In many graduate institutions, taking an undergraduate into a research group is considered an "overload." This attitude is difficult to defend. An undergraduate student can make a valuable contribution to a graduate research team, and at the same time, gain a valuable educational experience.

In spite of the differences between institutions with graduate programs as opposed to those that are strictly undergraduate, the consensus of the conference was that the individual faculty member in the graduate institution could handle no more, but probably could accommodate as many, undergraduate students as his counterpart in the undergraduate college.

In the graduate institution, the professor does have graduate or postdoctoral students to assist in coordinating

the work of undergraduates and is thus relieved of some of the routine supervision. However, the faculty member in this situation does have definite responsibilities in the training of graduate students. These are extremely time-consuming and may offset the gain realized by using graduate students to supervise undergraduates.

The number of students that any individual faculty member can conveniently accommodate is also governed by the need of the faculty to keep the student interested, and the need to communicate with the research participants on a regular basis. This seems to imply that the faculty member must, at least during the summers, concentrate primarily in supervising research activity rather than involvement in summer school teaching and other projects which may take the faculty member away from the campus.

The question of whether the research student should be paid and/or receive academic credits was difficult to resolve. The conference participants agreed that whenever possible a student should receive some remuneration for a full-time research activity during the summer in order to assist in college expenses. There was a general feeling that during the academic year the undergraduate was being given a special opportunity to enhance his or her education, and financial remuneration seemed less necessary -- and perhaps undesirable. Thus it may be

possible to distinguish between the "research student" and the "technician," with the latter being paid for effort rendered.

There was some feeling expressed that difficulties can arise in attempts to build a really positive attitude towards research when hourly pay is involved; the student who is paid may not be as conscientious as the one who has a personal commitment. An exception to this generalization may be the student who must work to stay in school.

The assignment of a grade to a student registered for research also poses a difficulty since the progress made in the project will depend upon the difficulty of the problem assigned, upon unexpected complications, and various other factors. The pass/fail grade seems to be one way to overcome this difficulty since now the faculty member need only make a qualitative judgment of the effort expended by the student. However, pass/fail may be counter to the educational concept of "teaching-research," and does eliminate the effort expended in the research from being considered in calculating a student's accumulative average.

An alternative procedure which has been used at at least one institution -- MIT -- involves giving a student an automatic pass for participation in a research project, but with the number of credits assigned determined by how productive the faculty member considers the student to have been. In

this system a student can receive one, two, three, or even four hours of credit for research participation, depending upon the factors judged important by the faculty. The system offers the advantage that the student can vary the time devoted to research depending upon the other requirements and, over a period of years, still be able to acquire a certain desired number of research credits. It also tends to reward the very conscientious and skilled student without the stigma which is sometimes attached to letter grades.

It does seem desirable to have the student who is to receive either pay or academic credit for research write a proposal at the beginning of the program describing what is to be done. This might be followed by regular written progress reports and finally with a terminal paper at the end of the project to be considered for submission for publication. Such a procedure gives the student the opportunity to see where a project should go, to gain experience in writing and organizing data, and to evaluate personally what has been accomplished. Such periodic reports are valuable in instructing students in how to write and how to communicate, two attributes which are often lacking. The student researcher should be taught that the reports should be concise and dependable, and that they will be used later in the preparation of the publication. Periodic reports also assist the faculty member in assuring that the student has a

good grasp of the literature and that progress continues to be made on the project.

It should be emphasized that these written reports should be secondary to day-to-day, or at least week-to-week, faculty contact with the student for broad discussions of the research under way.

Seminars are also useful for giving a student training in oral presentations and for keeping other students involved in the various research activities of the department. It is sometimes desirable to hold symposiums once or twice a year where some of the better -- more productive -- projects can be reported and discussed. This serves as a special stimulus to all students and is an excellent way to publicize the research activities of the department to students embarking on their academic training.

It should be emphasized that it is easier to determine when a project is progressing at a satisfactory pace than when it is not. The faculty supervisor should be constantly alert to problems which slow down the progress of research, and must be ready to take corrective action.

GETTING STUDENTS INVOLVED IN RESEARCH

An organized plan for informing students of the availability of research activities and encouraging their participation is a basic necessity. The plan should be tailored to the institution and will depend upon its enrollment, the number of faculty involved in research, and other conditions characteristic of the school. In the large college or university this indoctrination program will logically include written materials and announcements describing the research interests of the faculty members who will work with undergraduates.

Preliminary efforts can be followed by having the students meet, either individually or in groups, with the faculty members involved. Such a "free enterprise" system necessitates controls to insure an optimum distribution of students among faculty members.

In some instances it may be desirable to give some special consideration to the needs of young faculty members who have not yet attracted graduate student co-workers and who can, therefore,

profit most by an association with undergraduates. This is not necessarily to the disadvantage of the undergraduate, since such a faculty member may devote more time to the research project. Secondarily, the project will probably not be as highly organized and advanced as that of a senior faculty member with graduate co-workers.

In a large department it is often desirable to have one faculty member serve as undergraduate research coordinator. The coordinator can insure that all interested students are given the opportunity to do research in areas of special interest, and can distribute equally among the various faculty members the responsibility for supervising such activities. The coordinator can also serve as an ombudsman if difficulties arise, and exercise some control over the quality of training undergraduates receive.

In smaller institutions, and particularly those which are strictly undergraduate colleges, procedures may be somewhat less formal and may simply emphasize informal contacts between faculty members and interested students. In all probability, the student who is interested in participating in research will have already made the faculty aware of this interest and may already be acquainted with the projects which are available through informal contact with other research students. While formal announcements are less compelling in such a situation, every effort should be

made to encourage participation by those who are shy or reluctant to demonstrate overtly their special interests. The faculty must make an effort to identify students who can benefit from research participation, keeping in mind that some students have difficulty approaching faculty members directly.

The undergraduate research coordinator must be constantly alert to the fact that it is easier to attract students to certain areas of a discipline than to others. A student who has already had a course in a particular area will be more likely to select it for research participation than one to be studied later in the academic program, and will probably be better qualified to make a constructive contribution. Some special precautions might be taken, therefore, to see that faculty members teaching only upper-level undergraduate courses, or perhaps only graduate subjects, have a chance to participate with undergraduate students in meaningful research. This may necessitate some short seminar courses in the spring prior to a summer research program to establish the necessary background and training for the students.

As soon as a student has expressed interest in an area for concentration, he or she should be encouraged to digest the literature in the field prior to undertaking formal laboratory work. The recent publications of faculty members should also be made available to supplement oral and written presentations.

Initially the research supervisor may want to detail a problem at the level of the first experiment in order to get the student started on a productive course. A long lapse in time between the student's initial commitment and the actual starting point of a project may diminish the chances of a successful project. The selection of a research problem and the supervisor are the critical factors.

It should be emphasized to research supervisors that it is necessary to nurture and direct undergraduate research colleagues carefully in research activities since they are unfamiliar with this approach to science and may have difficulty developing the independent attitude which research requires.

Research need not be limited strictly to majors in the department under consideration, but can be opened to all students in the college who are qualified and who appear interested in participating. The non-science major may gain a great deal from even a limited research experience, providing that the student does have enough background to make a meaningful contribution.

Considerable time will have to be spent by the faculty member in personal discussions with each student during the early stages of an undergraduate research project. It was estimated by those participating in the conference that a faculty supervisor will spend up to two hours per day working

with each student during full-time summer research activity, and that three to five hours per week must be committed to a research group during the academic year.

These estimates are probably conservative for the early part of a research program which may require the faculty member to spend up to five hours a week working with each student until he or she gains experience.While exact demands will depend on the individual project and on the preparation of the students, supervision of undergraduate students in research is very time consuming.

A faculty member supervising undergraduate students during the summer is committed to a full work day. Such efforts during the academic year will require about as much time as that required to teach an individual course. The availability of graduate students may reduce this, but even with such assistance, the faculty member should plan to spend time with each undergraduate student -- perhaps an hour per week per student during the academic year and an hour per day during the summer. Such personal contact is critical if undergraduate research participation is to be a truly effective training technique.

Students should be welcomed and made to feel a part of the research group. Close cooperation and discussion between the faculty supervisor and all participating students are essential. Esprit de corps can be established when it is possible to provide

students with extra fringes, such as a desk in the laboratory for personal use, a key to the building, or other concessions not generally available to undergraduate students.

The faculty supervisor should guard against the tendency for an individual student to let his or her professional plans be dictated by the area of research concerned. The student should be given the opportunity to experience various alternative career opportunities. Normally research techniques in one field are applicable to others, but the faculty supervisor should be ever alert to see that the student is given a broadest possible experience.

Care must be taken to see that undergraduate students do not do research at the expense of their other academic training. This can best be monitored by the faculty research supervisor, but scholastic records should be periodically reviewed by the research coordinator. There was some feeling on the part of those at the conference that research participation should not be used to waive either general college requirements or specific requirements in a discipline. Thus research participation should be above and beyond the normal academic requirements.

A PRODUCTIVE RESEARCH ENVIRONMENT

There is no great mystery about factors which foster productive research. Basically they include the time to do research, support for equipment and operating expenses, the desire and ability on the part of the faculty to participate in this activity, and a productive departmental atmosphere. In essence, then, a productive research environment involves a commitment on both the part of the administration and the faculty.

At the present time and in the foreseeable future, financial management will be an important part of any research program. As discussed later in this report, funds are available from outside sources for the support of research but considerable effort is required to attract them.

Much research does necessitate the purchase of expensive equipment. Sound financial management indicates that such equipment can often serve a dual purpose in an institution: support of both a particular research project and of the teaching program of the department. In some cases equipment can be

shared between two or more disciplines in order to justify the original expenditure.

The young faculty member initiating a research program is well advised to attempt to match research with the facilities and the equipment either already available or to be made available in the near future. Some change in the direction of the research away from that involved in graduate or postdoctoral studies may well be required -- a factor which can sometimes foster originality.

The institution and the department will usually have to supply a significant portion of the equipment and supplies needed for research. The system in which all items obtained from a stockroom must be purchased and are non-returnable appears to result in considerable waste. It is advantageous if researchers can sign out or borrow equipment from the stockroom for use over a limited period of time and later return it for credit. Such a system does necessitate an accounting procedure and some safeguards to detect broken or damaged equipment, but it is the most economical way to meet the requirements of a number of students and faculty members undertaking different research projects.

GETTING INACTIVE FACULTY BACK INTO RESEARCH

Research involvement of faculty members with undergraduates has not been a traditional part of the academic offering at many undergraduate colleges and, in fact, a significant number of the college faculty members have had little involvement in research since completing formal academic training. It is difficult for such faculty members to reactivate their research interests.

Some faculty members cannot or do not want to do research. This may be due to special interests, other activities, or a feeling on the part of a faculty member that he or she no longer can initiate a problem of significance. However, as research becomes an integral part of the academic training of undergraduate students and as the enthusiasm of the students increases, many inactive faculty members will inevitably be pulled back into research participation.

The institution can encourage activity in a variety of ways. One important technique involves the recognition in

assigning teaching loads that time spent working with undergraduates is a part of the training program and that faculty members so occupied should be given credit. Financial support from the institution and recognition from the college's administrators also helps spur faculty research activities.

A sabbatical leave or comparable leave of absence may assist a faculty member in reviving research activities. Collaboration between a faculty member at a university offering a graduate program and a faculty member at an undergraduate institution may be an effective vehicle for initiating a research program at the latter institution. In such a program the college staff member may spend time on the university campus during a leave of absence, over the summer, or as time permits. After such an initiation period the individual should be able to take a portion of the research problem back to the campus for further investigation. Experimentation along these lines is under way at the University of Wisconsin in Milwaukee.

Another technique which has proven successful in assisting research-inactive faculty involves their collaboration with faculty members having active research programs. Initially the inactive person may undertake that portion of the activity for which he or she feels qualified, but under the direction of the investigator who originated the problem. It may be found that the cooperative or team research approach is particularly

productive for all concerned, or a more independent arrangement may evolve as the research generates new problems for investigation.

The initiative for making a department really active in research must usually come from the administration. The administration can often catalyze research activity by giving public or private recognition to grants received and to accomplishments which result from research. If the administration also acknowledges that undergraduate research is a part of good teaching and should be rewarded, it will create a powerful stimulus for such activity. If necessary, the faculty must acquaint the administration with the importance of research to faculty and students.

The clue to an active research program does not seem to be in the so-called "reduced teaching load" but in giving teaching credit to the faculty member involved in research supervision. Thus research-teaching should be a part of the active responsibility of faculty members, at least in the natural sciences. This fact may not be readily recognized at many institutions, and acceptance of it should be fostered by those with research interests. It is, of course, difficult to sell the importance of research-teaching in an institution which does not have a history of research involvement, since many disciplines are not research oriented.

The involvement of faculty in research does have a positive impact on classroom teaching. Interest in contributing to the advancement of science through research participation stimulates the faculty to keep abreast of new developments. This knowledge and stimulation is then carried over into the classroom. A previously mentioned study[1] involving the analysis of student evaluation of instructors at Kansas State University indicated a linear trend between the degree of research involvement of the faculty on the one hand, and the amount of reading done by students and their perceived difficulty of the courses on the other. In the natural sciences, adjusted student progress ratings steadily increased as the instructor's level of research involvement increased. Faculty members with heavy teaching responsibility were shown to set higher academic standards than those less involved. The report concluded that the findings offer support to the assumption that research involvement helps broaden the teacher and thus improves the individual's ability to foster broad understanding.

WHAT RESULTS CAN BE EXPECTED FROM UNDERGRADUATE RESEARCH?

The goal of a research problem should be to uncover new information which will be of interest and significance to the scientific community.

This goal applies to all research, regardless of the sophistication of the investigator. In the case of research in an undergraduate institution -- research involving a faculty member and students -- the frequency with which publications appear depends directly upon the area under investigation. In some research areas a publication may result after one summer of intensive work, whereas in others cumulative effort of perhaps three years may be required before there is a single article. For the personal satisfaction of the investigator and the students involved, as well as the professional reputation of the faculty member, something between these two extremes would appear to be desirable. It will probably be difficult to sustain enthusiasm if publications appear less frequently than one in three years.

Experience has shown that faculty and students must be involved in real problems to sustain interest in research -- that is, problems which have the potential for advancing science and which are able to withstand the scrutiny of the investigator's peers. Peer review may take place when applications are submitted for research support, when papers are submitted for publication with student co-authors, or in seminars before professional groups.

Research problems undertaken by faculty working solely with undergraduate students can and do result in publications. Of the group participating in this conference, an average of slightly less than one publication per faculty member in a professional journal resulted in a year, with as many as four resulting in some cases. It should be recognized that this group was selected for research performance, but the figures do demonstrate that the instructor in the undergraduate college can also be a productive scientist.

In the typical undergraduate class laboratory, the student is indoctrinated in the principles and precepts of science and receives training in experimental techniques. To stop at this point, however, is to leave the student with an incomplete experience. The student must be given the opportunity to put this training into practice in real-life situations in order to fully comprehend the nature of science. Research -- the

process of discovery and explanation -- offers the ideal vehicle for the student to experience science in action.

In the classroom the concept of the scientific method is often discussed without being adequately defined. Later the student discovers that there is no single scientific method, but a body of such methods. Likewise, the scientist does not think and act in a fixed, well-defined conceptual framework. This variation in "science" and scientific methods is best brought to bear on the student during research participation, for it is here that the student experiences science in action.

The student who participates in research with a faculty colleague is sure to acquire a sense of pride and accomplishment in creativity, as well as a sense of belonging to an active department. Such a student, with a bright, eager, enthusiastic attitude, can be of great assistance to the institution in recruiting other students. The combination of a student having worthwhile and rewarding research experience and an equally enthusiastic faculty member will result in an effective recruiting team.

The faculty member who is involved in research is obviously a practicing scientist. This will be important in gaining the special respect of the students. It has been observed that undergraduates often hold research faculty members in greater esteem than those less active. The faculty

with active research interests also makes a positive contribution to the image of the college. The presence of faculty and students involved in laboratory work can make a favorable impact on prospective students, and publication of this activity can be used to convince high school teachers and guidance counselors that faculty members are concerned with the student's welfare as well as with their own professional competence.

Disadvantages cited in connection with undergraduate research include one involving the division of labor during the academic year. It is the responsibility of the research supervisor to see that research in no way infringes on the student's formal classroom training or on the overall educational preparation for life which the student is expected to receive as an undergraduate.

Research is an expensive activity and will cost an institution money. Limited budgets can be supplemented if the faculty can attract outside support, but the institution should understand that an expenditure will be required if only in the form of overhead expenses. It is the responsibility of the individual investigator to convince those in authority that the benefits of research participation far outweigh the financial disadvantages.

It is true that undergraduate students who continue on in graduate school will get research experience at that level of

training. This does not, however, negate the advantage of a preliminary exposure to research obtained during the undergraduate program. It has been observed many times that new graduate students who have had experience in research as undergraduates have already developed a degree of independence which assists the transition into graduate studies. The techniques learned as an undergraduate can be valuable in graduate training.

The opportunity to participate in research is also of great value to the student who does not intend to pursue further study in the sciences. This may be the only exposure the terminal bachelor's degree student will have with true research, yet such experience is necessary to have a real understanding of science.

Research participation will also be of value to students who choose careers in other fields such as medicine, government and business, since this training offers the student the chance to experience science as it really is. It is perhaps the best technique for teaching the "scientific method." Thus, when research is offered to the undergraduate student at an age before the student has made a final commitment to a career, the individual has the opportunity to decide, with some degree of expertise, whether a career in science will be his choice.

THE COST OF RESEARCH

The principal costs of research participation involve stipends, supplies and equipment. The actual costs in the undergraduate institution depend upon many factors, including availabilty of equipment needed for research as part of the science curriculum.

Institutions which have had active research programs in recent years have purchased much equipment with matching funds from various outside agencies. In the majority of cases these grants have required matching funds from the home institution. Table II summarizes the four year experience of one undergraduate college chemistry department.

Table II

FUNDS REQUESTED AND OBTAINED FOR SUPPORT OF CHEMISTRY DEPARTMENT AT ONE PARTICIPATING COLLEGE

	Number			$000		
	Requests	Funded	Pending	Requested	Funded	Pending
Equipment	11	7	1	175.4	88.4	49.8
Single project research	13	8	2	185.4	99.5	31.8
Multi-investigator research	9	7	0	290.6	57.1	0

It is currently more difficult to generate such matching money due to the fact that less money is and may in the future be available from outside sources than has been the case in the past. When one considers that the cost of scientific research is escalating at a very rapid rate, it is apparent that money problems will increase in severity. To assure success in attracting outside support, numerous applications must be submitted. As shown in Table III, many will not be funded.

Table III

SUPPORT REQUESTED AND RECEIVED BY PARTICIPATING UNDERGRADUATE DEPARTMENTS DURING ONE-YEAR PERIOD

	Number Applications	Number Approved	% Approved
Petroleum Research Fund	13	7	54
National Science Foundation	19	5	26
National Institutes of Health	4	1	25
Other federal	10	1	10
All others	7	4	57
Total	53	18	34

A recent study of Research Corporation grantees from undergraduate colleges showed that of those who tried for further support, a surprising number were successful. But for unexplained reasons many did not seek further support. Thus of 33 grantees with projects under way for one to four years, 11 had not

applied for additional support. Of the 22 who had, 53 applications were submitted and 21 were funded.

The cost of doing research may limit the scope of an undergraduate project and perhaps the number of students who can be involved. Investigators just getting started in research, as well as those who have been active over the years, may have to adjust their programs to the equipment already available at the institution or to that which can readily be obtained. For this reason some research may simply be impractical at an undergraduate institution, even though the investigator has a problem that qualifies in all other respects.

In some cases it may be possible to share equipment between institutions, such as between two neighboring colleges of similar size, or between a college and a neighboring university or research installation. There is a significant amount of scientific equipment at many institutions which is available at least some of the time. Such equipment might be made accessible to the really innovative investigator. There are also commercial "clearing houses" which sell unused equipment at reasonable prices. It is often possible for an investigator to borrow, or rent, equipment from another institution or from a government laboratory. Contact for this purpose is best made between individuals.

There are examples of universities which have established

endowments for the sole purpose of supporting research. Such an arrangement is quite desirable and a proposal to this effect should be contained in the portfolio of the college or university's development office.

Assuming that some equipment is available at the institution for the support of a particular project, some generalizations can be made on the cost of an individual research problem.

The consensus of the group participating in this conference was that, at the minimum, it would cost between $1400 to $1800 to support an undergraduate research student for a twelve-month period. This would include a summer stipend for the undergraduate in the range of $600 to $1000, plus the cost of supplies and expendable equipment. The assumption is made that the home institution will be able to provide some routine and re-usable equipment and needed instrumentation.

This figure does not include summer stipends for the principal investigator who is supervising the research, nor does it include overhead expenses. Obviously the latter is important; it is hoped that the institution will undertake this cost as a part of the expense of training students. Grants in support of students in the range mentioned above are currently available in most areas of the physical sciences from various federal and private agencies. Additional help can often be obtained from interested alumni and from local residents and

industries.

As an example, the cost of supporting a research program involving ten undergraduates and five faculty members at one of the participating institutions for one year was $28,000. Support was obtained from two outside sources in addition to that provided by the university.

WHAT DOES THE FUTURE HOLD?

In recent years foundation support of basic research has been decreasing and there is reason to suspect that this trend may continue in the foreseeable future. Even in the post-Sputnik era when it reached its peak, support of the physical sciences from this source was not nearly as great as commonly assumed. A summary of foundation grants from the period 1961 to 1967 shows that only 7% of the total number of dollars given went for support of work in physical sciences. The relative position of science as a recipient of foundation grants over $10,000 is shown in Table IV, compiled by The Foundation Center, New York.

TABLE IV

FOUNDATION SUPPORT BY FIELD, 1961-1970

	$000,000	%
Education	1,824	32
International activities	850	15
Health	814	14
Welfare	710	13
Sciences (physical, life, social)	708	12
Humanities	485	9
Religion	269	5
Total	5,660	100

While some of the large national foundations are logical sources of funds for research, it may be more productive to approach local and company foundations for funding. The individual investigator in need of financial support can find the fields of interest and the names of the trustees of foundations in the area in order to make a personal approach. Such information can be obtained from a variety of sources, including the Regional Collections which cooperate with The Foundation Center, which are listed in the Appendix.

It may also be profitable to check with local banks to see which discretionary funds they administer, and with local attorneys who are responsible for handling trusts. In both cases the investigator should acquaint money managers with the academic institution and the needs of its researchers.

Cultivating and enlisting the aid of an enlightened development office can also be extremely helpful to the individual faculty member or department in assisting in securing funding.

Federal funding will probably remain the major source of support for the sciences, and administrators and investigators might see that their representatives in Congress know what is happening at the college and are acquainted with its needs. There are a number of ways that an individual citizen can influence funding. One is to invite legislators representing the district in question to visit the campus to see what has

been done with funds obtained previously. This will allow the legislator to become acquainted with the needs of the institution and the personnel involved. Even when legislators are not able to accept an invitation, they might be kept informed of activities on the campus.

In the face of the larger financial and enrollment problems which are critical today, funding for undergraduate research may take a low priority in the eyes of college and university administrators. If these overall problems become more severe, as some expect them to, it will become still more difficult to secure institutional funding. It then becomes the responsibility of the leader of the research team to make every attempt possible to see that the undergraduate program is run in the most economical fashion, and that the demands placed on the institution are consistent with its best interests. At the same time, those who are really dedicated to the concept of undergraduate research will seek outside sources of funding for that portion of the load that the institution cannot legitimately bear when confronted with its other obligations.

CONCLUDING REMARKS

Research is an important part of teaching, especially of quality teaching, in the natural sciences. It needs to be so recognized and rewarded. It would be preferable to refer to this activity as "research-teaching," and to consider it a part of the academic responsibility of the institution as opposed to an extracurricular activity.

Such recognition will go a long way toward sustaining active research facilities in the physical sciences at the undergraduate level of education in this country.

The involvement of faculty in research education has been shown to have a positive impact in classroom teaching. Research participation stimulates the faculty to keep abreast of new developments. This knowledge and stimulation is quickly transferred to the classroom. Thus, participation in research, in addition to the benefits for the students, represents effective faculty development among science teachers at the undergraduate level of higher education.

APPENDIX

SOURCES OF INFORMATION ON FOUNDATIONS

NATIONAL COLLECTIONS

The Foundation Center, 888 Seventh Avenue, New York, N.Y. 10019
The Foundation Center, 1001 Connecticut Avenue, N.W., Washington, D.C. 20036
Donors' Forum, 208 South LaSalle Street, Chicago, Illinois 60604

REGIONAL COLLECTIONS

	Geographical Coverage
ALABAMA Birmingham Public Library 2020 Seventh Avenue, North Birmingham 35203	*Alabama*
ARKANSAS Little Rock Public Library Reference Department 700 Louisiana Street Little Rock 72201	*Arkansas*
CALIFORNIA University Research Library Reference Department University of California Los Angeles 90024	*Alaska, Arizona, California, Colorado, Hawaii, Nevada, Utah*
San Francisco Public Library Business Branch 530 Kearny Street San Francisco 94108	*Alaska, California, Colorado, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming*
COLORADO Denver Public Library Sociology Division 1357 Broadway Denver 80203	*Colorado*
CONNECTICUT Hartford Public Library Reference Department 500 Main Street Hartford 06103	*Connecticut, Massachusetts, Rhode Island*
FLORIDA Jacksonville Public Library Business, Science, and Industry Department 122 North Ocean Street Jacksonville 32202	*Florida*
Miami-Dade Public Library Florida Collection One Biscayne Boulevard Miami 33132	*Florida*
GEORGIA Atlanta Public Library 126 Carnegie Way, N.W. Atlanta 30303	*Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia*
HAWAII Thomas Hale Hamilton Library Humanities and Social Sciences Division 2550 The Mall Honolulu 96822	*California, Hawaii, Oregon, Washington*
IOWA Des Moines Public Library 100 Locust Street Des Moines 50309	*Iowa*
KANSAS Topeka Public Library Adult Services Department 1515 West Tenth Street Topeka 66604	*Kansas*
KENTUCKY Louisville Free Public Library Fourth and York Streets Louisville 40203	*Kentucky*
LOUISIANA New Orleans Public Library Business and Science Division 219 Loyola Avenue New Orleans 70140	*Louisiana*
MAINE University of Maine at Portland-Gorham Center for Research and Advanced Study 246 Deering Avenue Portland 04102	*Maine*
MARYLAND Enoch Pratt Free Library Social Science and History Department 400 Cathedral Street Baltimore 21201	*Maryland*
MASSACHUSETTS Associated Foundation of Greater Boston One Boston Place, Suite 948 Boston 02108	*Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont*
Boston Public Library Copley Square Boston 02117	*Massachusetts*
MICHIGAN Henry Ford Centennial Library 15301 Michigan Avenue Dearborn 48126	*Michigan*
Grand Rapids Public Library Sociology and Education Department Library Plaza Grand Rapids 49502	*Michigan*
MINNESOTA Minneapolis Public Library Sociology Department 300 Nicollet Mall Minneapolis 55401	*Iowa, Minnesota, North Dakota, South Dakota*
MISSISSIPPI Jackson Metropolitan Library 301 North State Street Jackson 39201	*Mississippi*

MISSOURI	
Kansas City Public Library 311 East 12th Street Kansas City 64106	*Kansas, Missouri*
The Danforth Foundation Library 222 South Central Avenue St. Louis 63105	*Iowa, Kansas, Missouri, Nebraska*
MONTANA	
Eastern Montana College Library Reference Department Billings 59101	*Montana*
NEBRASKA	
Omaha Public Library 1823 Harney Street Omaha 68102	*Nebraska*
NEW HAMPSHIRE	
The New Hampshire Charitable Fund One South Street Concord 03301	*New Hampshire*
NEW JERSEY	
New Jersey State Library Reference Section 185 West State Street Trenton 08625	*New Jersey*
NEW YORK	
New York State Library State Education Department Education Building Albany 12224	*New York*
Buffalo and Erie County Public Library Lafayette Square Buffalo 14203	*New York*
Levittown Public Library Reference Department One Bluegrass Lane Levittown 11756	*New York*
Rochester Public Library Business and Social Sciences Division 115 South Avenue Rochester 14604	*New York*
NORTH CAROLINA	
William R. Perkins Library Duke University Durham 27706	*North Carolina*
OHIO	
The Cleveland Foundation Library 700 National City Bank Building Cleveland 44114	*Michigan, Ohio, Pennsylvania, West Virginia*
OKLAHOMA	
Oklahoma City Community Foundation 1300 North Broadway Oklahoma City 73103	*Oklahoma*
OREGON	
Library Association of Portland Education and Psychology Department 801 S.W. Tenth Avenue Portland 97205	*Alaska, California, Hawaii, Oregon, Washington*
PENNSYLVANIA	
The Free Library of Philadelphia Logan Square Philadelphia 19103	*Delaware, New Jersey, Pennsylvania*
Hillman Library University of Pittsburgh Pittsburgh 15213	*Pennsylvania*
PUERTO RICO	
Consumer Education and Service Center Department of Consumer Affairs Minillas Central Government Building North Santurce 00908	*Puerto Rico*
RHODE ISLAND	
Providence Public Library Reference Department 150 Empire Street Providence 02903	*Rhode Island*
SOUTH CAROLINA	
South Carolina State Library Reader Services Department 1500 Senate Street Columbia 29211	*South Carolina*
TENNESSEE	
Memphis Public Library 1850 Peabody Avenue Memphis 38104	*Tennessee*
TEXAS	
The Hogg Foundation for Mental Health The University of Texas Austin 78712	*Arkansas, Louisiana, New Mexico, Oklahoma, Texas*
Dallas Public Library History and Social Sciences Division 1954 Commerce Street Dallas 75201	*Texas*
UTAH	
Salt Lake City Public Library Information and Adult Services 209 East Fifth Street Salt Lake City 84111	*Utah*
VERMONT	
State of Vermont Department of Libraries Reference Services Unit 111 State Street Montpelier 05602	*New Hampshire, Vermont*
VIRGINIA	
Richmond Public Library Business, Science, & Technology Department 101 East Franklin Street Richmond 23219	*Virginia*
WASHINGTON	
Seattle Public Library 1000 Fourth Avenue Seattle 98104	*Washington*
WEST VIRGINIA	
Kanawha County Public Library 123 Capitol Street Charleston 25301	*West Virginia*
WISCONSIN	
Marquette University Memorial Library 1415 West Wisconsin Avenue Milwaukee 53233	*Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, Wisconsin*
WYOMING	
Laramie County Community College Library 1400 East College Drive Cheyenne 82001	*Wyoming*